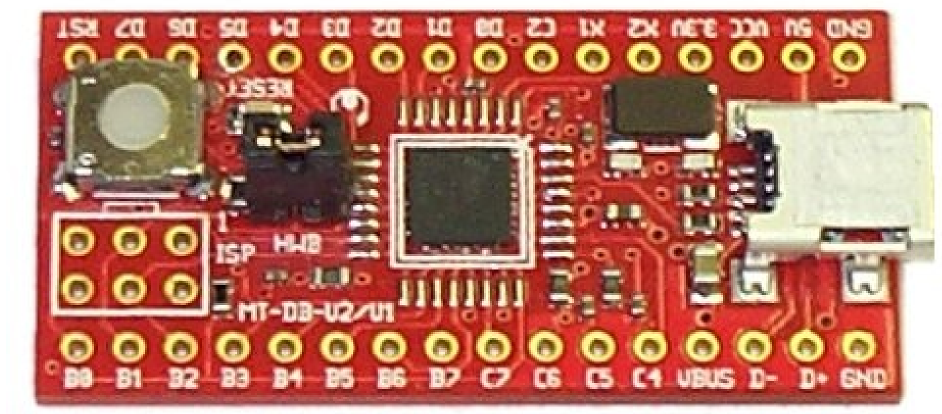
MT-DB-U2 Manual



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Overview

Introduction

The MT-DB-U2 is a development board for the Atmel ATmega32U2 USB microcontroller. The Atmega32U2 contains 32 KB of flash, 1 KB of RAM, 1 KB EEPROM, 22 programmable IO pins, and a USB device controller. The board has 32 pins in a dual inline configuration with 100 mil pin spacing and 600 mil row spacing which allows for easy mounting on a breadboard. It includes a mini USB connector, status LED, 16MHz crystal, reset button, HWB boot jumper, 3 PWM filters, and ISP header pads. A bootloader comes preinstalled which allows programming of the chip over USB without an external programmer. The ISP header can be used with an external programmer for in-system programming. This header can be reconfigured to allow the MT-DB-U2 itself to be an ISP programmer, or to be used as a SPI master or slave. The board can be powered at 5V via USB, at 3.3V via the ATmega32U2 internal regulator and USB, or it can be powered externally (3V – 3.6V or 4.0V – 5.5V). All programmable IO pins are routed to headers, including those used by on-board hardware. The chip can be clocked externally, and the board is compatible with HV programming. The USB connections are also routed to header pins, which allows for panel-mount USB connectors. The PCB is high-quality with ENIG (gold-plated) finish, red soldermask, and white screenprinting showing the pinout. It measures approximately 1.7” x 0.8” (42mm x 20mm) and is 0.062” (1.6mm) thick.

MT-DB-U2 Features

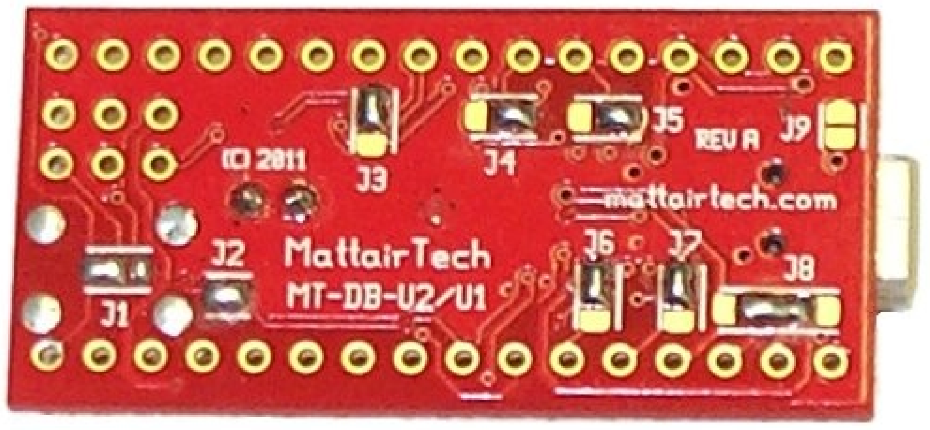
- ATmega32U2 USB microcontroller
  - 32KB FLASH, 1KB SRAM, 1KB EEPROM
  - USB device controller, Serial USART, and SPI communications
  - 2 timers with 5 PWM channels
- Arduino compatible
- CDC (Arduino/AVRDUDE) or DFU (FLIP) bootloader preinstalled
- Bitlash preinstalled (Arduino command shell)
- ISP header pads (program chip using external programmer)
- 16MHz crystal
- Green Status LED
- 3 RC PWM filters on each output compare pin of 16-bit timer 1 (can be disconnected)
- Reset button
- Bootloader selection jumper
- Mini USB connector
- Can be powered via USB at 5V (Vbus) or 3.3V (ATmega32U2 internal regulator)
- Can be powered externally at 3V to 3.6V or 4V to 5.5V
- All programmable IO pins routed to headers (including those used by on-board hardware)
- USB pins routed to header pins (for panel-mount USB connector)
- High-quality PCB with gold-plated finish and red soldermask
- DIL-32 board, standard 0.1" pin spacing. Can be mounted on a breadboard
- Measures approx. 1.7” x 0.8” (42mm x 20mm) and 0.062” (1.6mm) thick.

ATmega32U2 Features

- **High Performance, Low Power AVR® 8-Bit Microcontroller**
- **Advanced RISC Architecture**
  - 125 Powerful Instructions – Most Single Clock Cycle
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 Mhz
- **Non-volatile Program and Data Memories**
  - 32K Bytes of In-System Self-Programmable Flash
  - 1024 Bytes EEPROM
  - 1024 Bytes Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/ 100,000 EEPROM
  - Data retention: 20 years at 85°C/ 100 years at 25°C(1)
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by on-chip Boot Program
    - True Read-While-Write Operation
  - Programming Lock for Software Security
- **USB 2.0 Full-speed Device with Interrupt on Transfer Completion**
  - Complies fully with Universal Serial Bus Specification REV 2.0
  - 48 MHz PLL for Full-speed Bus Operation: 12 Mbit/s data rate
  - Fully independant 176 bytes USB DPRAM for endpoint memory
  - Endpoint 0 for Control Transfers: from 8 up to 64-bytes
  - 4 Programmable Endpoints:
    - IN or Out Directions
    - Bulk, Interrupt and IsochronousTransfers
    - Programmable maximum packet size from 8 to 64 bytes
    - Programmable single or double buffer
  - Suspend/Resume Interrupts
  - Microcontroller reset on USB Bus Reset without detach
  - USB Bus Disconnection on Microcontroller Request
- **Peripheral Features**
  - One 8-bit Timer/Counters with Separate Prescaler and Compare
    - (two 8-bit PWM channels)
  - One 16-bit Timer/Counter with Prescaler, Compare and Capture
    - (three 8-bit PWM channels)
  - USART with SPI master mode and hardware flow control (RTS/CTS)
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
  - Interrupt and Wake-up on Pin Change
- **On Chip Debug Interface (debugWIRE)**
- **Special Microcontroller Features**
  - Power-On Reset and Programmable Brown-out Detection
  - Internal Calibrated Oscillator
  - External and Internal Interrupt Sources
  - 5 Sleep Modes: Idle, Powersave, Powerdown, Stby., and Ext. Stby.
- **I/O and Packages**
  - 22 Programmable I/O Lines

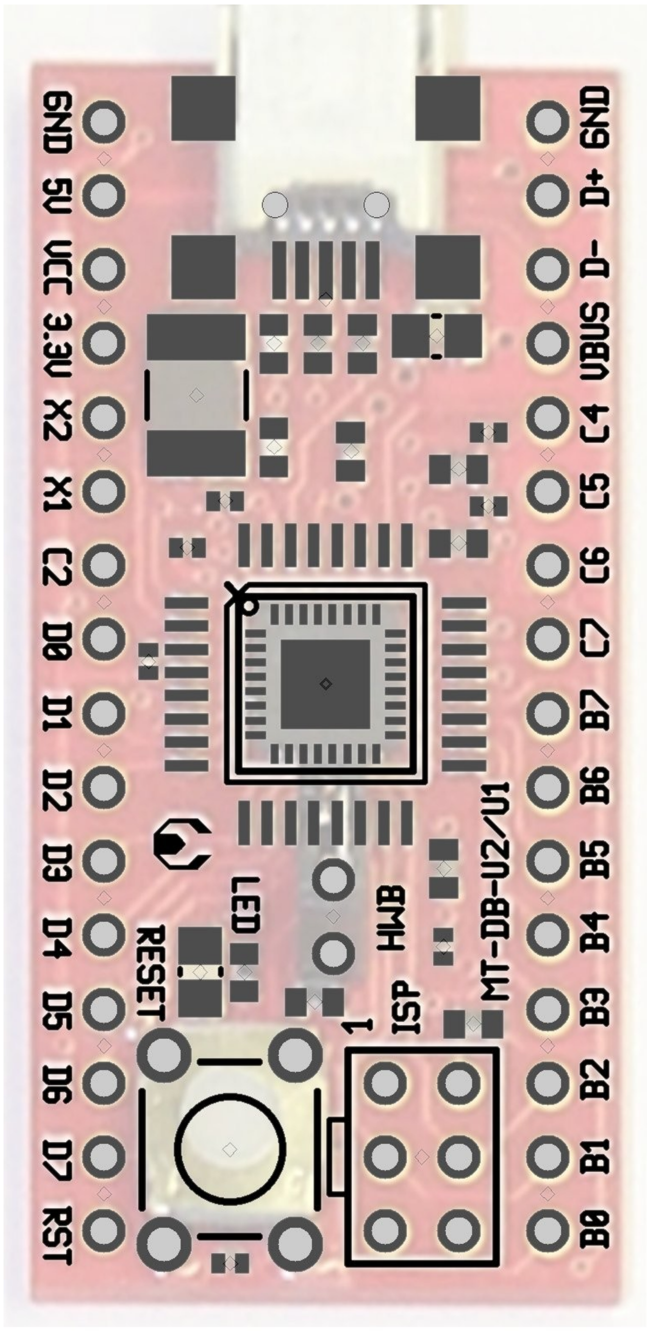
QFN32 (5x5mm) / TQFP32 packages

- **Operating Voltages**
  2.7 – 5.5V
- **Operating temperature**
  Industrial (-40°C to +85°C)
- **Maximum Frequency**
  8 MHz at 2.7V - Industrial range
  16 MHz at 4.5V - Industrial range

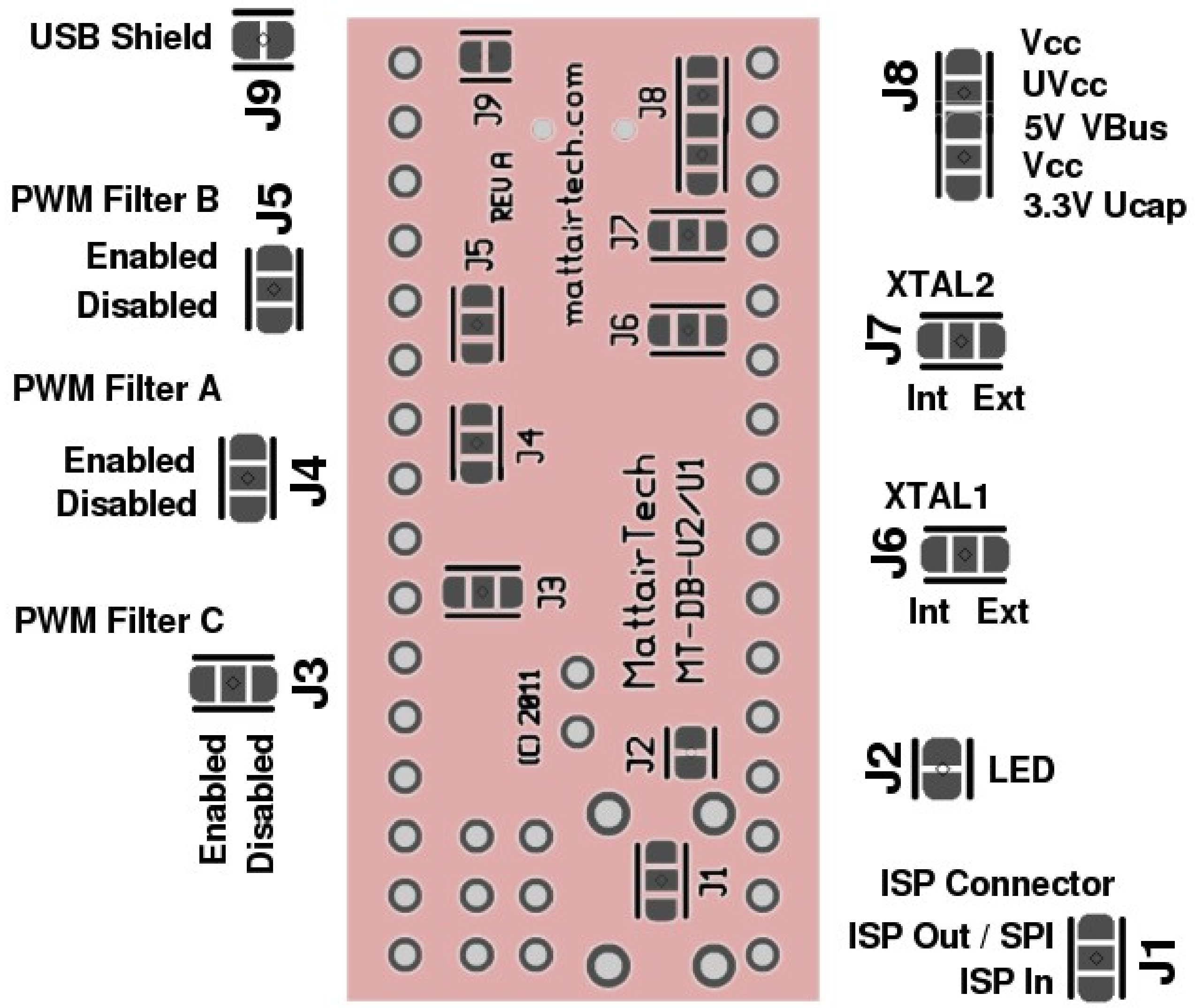


MT-DB-U2 Hardware

Layout / Header Pins



Solder Jumpers



Pin Descriptions

Pin	Description
Gnd	Ground
5V, Vbus	5V output from USB Vbus. Vbus pin and 5V pin are tied together.
Vcc	Voltage input pin. Use solder jumper J8 to configure. This pin is connected to the Vcc and AVcc pins on the microcontroller, as well as the ISP header and reset pullup. See Power Configuration Section.
3.3V	3.3V output from the microcontroller internal 3.3V regulator. This pin is connected to Ucap on the microcontroller.
X2 (C0)	This pin can be connected to the XTAL2 pin of the microcontroller using jumper J7. This is useful if pin C0 is used as GPIO (if external clock is used). This pin is disconnected by default (onboard crystal is used).
X1	This pin can be connected to the XTAL1 pin of the microcontroller using jumper J7. This is useful if an external clock is used. This is also useful for HV programming or recovery from incorrectly set fuses. This pin is disconnected by default (onboard crystal is used).
C2	GPIO pin (Port C) Consult datasheet for functionality.
D0 - D7	GPIO pins (Port D) Consult datasheet for functionality.
D0 / LED	The green status LED is connected to this pin when solder jumper J2 is set. The LED is connected to ground through a 240 ohm resistor. The user application is free to use this LED. Drive the pin high to turn on the LED.
D7 / HWB	This pin is connected to the bootloader jumper (HWB). The jumper is connected to ground through a 240 ohm resistor. The pin is sampled after all reset sources, including power-up. If the pin is low (HWB jumper installed), then the bootloader is run. If the pin is high (HWB jumper removed), then the user application is run. This pin functions as a normal GPIO pin at all other times. The 240 ohm resistor provides short-circuit protection in case the pin is used as an output and the jumper is installed.
RST	Connects to reset pin of microcontroller as well as the reset button. A 10K pullup resistor and 100nF capacitor are connected to this pin. If jumper J1 is set to ISP In, then RST is also connected to pin 5 of the ISP header.
B0 - B6	GPIO pins (Port B) Consult datasheet for functionality.
B7	PWM filter C output (OC.1C) or pin B7, depending on jumper configuration.
C4, C7	GPIO pins (Port C) Consult datasheet for functionality.
C5	PWM filter B output (OC.1B) or pin C5, depending on jumper configuration.
C6	PWM filter A output (OC.1A) or pin C6, depending on jumper configuration.

D+, D-	USB data pins. Can be used for panel-mount connectors.

PWM Filters

There are three PWM filters, which can be used to smooth out a PWM square wave into an analog voltage (with some ripple). The outputs of these filters can be connected to header pins C6, C5, and B7 using solder jumpers J4, J5, and J3 respectively (factory default). The filters consist of a 1K resistor and 100nF capacitor. The cutoff frequency is:

$$f_{3db}=1/(2\pi RC)=1/(2\pi 1\mathrm{K}*100\mathrm{nF})=1/(2\pi 0.0001)=1600Hz$$

This is a first-order low-pass filter that can output levels from 0V to Vcc. All three filter inputs are connected to the 16-bit timer 1 output compare pins (OC.1A, OC.1B, and OC.1C). The filter inputs are always connected to the microcontroller. Therefore, if the solder jumpers are configured to connect the microcontroller pins directly to the header pins, there will be some loading on the pin (1K resistor in series with a 100nF capacitor to ground).

Clock Source

By default, a 16 MHz crystal is installed and connected to the XTAL pins of the Atmega32U2. This 16 Mhz clock must be divided by 2 in software if the Vcc voltage is less than 4.5V. If an external clock is is used, solder jumper J6 can be switched to connect the microcontroller pin directly to header pin rather than the onboard crystal. An external clock signal can then be applied to pin X1 (XTAL1). This will also free up microcontroller pin C0 (XTAL2), which can be configured in the microcontroller as a GPIO pin and routed to header pin X2 by switching solder jumper J7.

HWB Jumper / RESET button / LED

The HWB Jumper is used to select either the bootloader or user application. The pin is sampled after reset or power-up. Note that the hardware HWB function of the ATmega32U2 is disabled. That is, the HWBE fuse is disabled. The bootloader startup code is always run after reset or power-up (BOOTRST fuse is set). The code samples the state of the HWB pin. If the pin is low, the bootloader continues to run. If the pin is high, the user application is run. The green LED will pulse on and off using a continuously changing PWM period when the DFU bootloader is running. If the preinstalled demo program is running, it will be lit when USB is connected. Otherwise, the state of the LED is controlled by the user application. The bootloader always runs at 8 MHz, which is compatible with lower voltages. The user may set the cpu speed to 16MHz in software, if running at 5V.

Jumper	*Mode*	*Driver*
No	User Program	CDC (COM port) (*optional*)
Yes	Bootloader Program	CDC Serial/DFU Bootloader

It is not necessary to remove and replace the jumper when switching between the bootloader and the user application. The jumper can be left on. After FLASH programming, the CDC bootloader will automatically jump to the application. If using the DFU bootloader, then you can command FLIP or dfu-programmer to jump to the application. Then, when running the application, the reset button can be pressed to re-enter the bootloader. This is useful when writing and debugging firmware. When the firmware is complete, the jumper can be removed so that future resets will always run the application.

The pins associated with the LED, jumper, and reset button are all routed to header pins. The LED can be disconnected by unsoldering jumper J2. The jumper is connected to pin D7 on one side and to ground through a 240 ohm resistor on the other side. There is a 10K pullup on the reset line.

ISP Header

The ISP header is configured by default to allow ISP programming using an external programmer. That is, RESET is routed to pin 5. Pin 1 is marked on the board (it is the pin closest to the chip). The ISP header can be reconfigured so that pin PB0 (SS) is connected to pin 5 rather than RESET. This can be done by switching solder jumper J1. This allows the MT-DB-U2 to be used as an AVRISPmkII programmer itself, using Dean Camera's AVRISPmkII software available at http://www.fourwalledcubicle.com/. A precompiled hex file will be made available at http://www.mattairtech.com/ on the MT-DB-U2 product page. Note that when using the ISP header in this way, Vcc and ground are output to the target board. Therefore, the target board should not be powered itself. You should also verify that it is safe to power the target board through the ISP connector. Another use for the ISP header configured with SS on pin 5 is to make use of SPI, either as a master or slave. SPI can also be used on the normal DIL headers. When using the ISP header, you may need to remove the HWB jumper to allow the ISP connector to fit.

Power Configuration

The MT-DB-U2 can be powered in a variety of ways by utilizing solder jumper J8 located on the bottom of the board. By default, the board is configured to be powered via USB, with Vcc at 5V, and the microcontroller internal 3.3V regulator enabled and powering only the USB pads. The microcontroller clock is configured at boot to run at 8MHz. The following lists some of the configurations possible. Code may have to be re-compiled when switching configurations (ie: to change cpu clock speed and/or internal regulator power).

Power Configuration	Jumper J8	Regulator	Max CPU
USB bus powered – 5V Vcc (default)	**3.3V Vcc = 5V = UVcc Vcc**	Enable	16 MHz
USB Bus powered – 3.3V Vcc	**3.3V = Vcc 5V = UVcc Vcc**	Enable	8 MHz
Externally powered – 4.0 to 5.5V Vcc	**3.3V Vcc 5V UVcc = Vcc**	Enable	16 MHz
Externally powered – 3.0 to 3.6V Vcc	**3.3V = Vcc 5V UVcc = Vcc**	Disable	8 MHz

WARNING

Care must be taken when configuring the solder jumpers.
It is possible to cause permanent damage to the device or the power supply by improperly setting the jumpers.
Do not change any jumpers while the unit is powered.
When using the microcontrollers internal regulator to power itself, be sure not to exceed the regulator maximum current output.

USB Bus Powered -- 5V

By default, the MT-DB-U2 is configured for 5V from the USB connector (Vbus). In this configuration, solder jumper J8 is set such that Vcc and UVcc are connected to Vbus (5V). The AVR internal 3.3V regulator must be enabled (default setting). This will supply 3.3V to the USB pads and 3.3V header pin.

USB Bus Powered – 3.3V

The internal 3.3V regulator can be used to supply the AVR itself with 3.3V. In this configuration, solder jumper J8 is set such that Vcc is connected to 3.3V and UVcc is connected to Vbus (5V). The AVR internal 3.3V regulator must be enabled (default setting). This will supply 3.3V to the AVR itself, the USB pads, and the 3.3V header pin. Take care not to exceed the datasheet maximum current output of the internal regulator. Note that at 3.3V, the AVR should be set to run at 8MHz or less. This can be done in software using the prescaler.

Externally Powered – 4.0V to 5.5V

In this configuration, solder jumper J8 is set such that UVcc is connected to Vcc. Vcc is then supplied externally with 4.0V to 5.5V on the Vcc header pin. The 5V pin still outputs 5V when the USB cable is plugged in. The AVR internal 3.3V regulator must be enabled (default setting). This will supply 3.3V to the USB pads and 3.3V header pin. Note that when using a voltage less than 4.5V, the AVR should be set to run at 8MHz or less. This can be done in software using the prescaler.

Externally Powered – 3.0V to 3.6V

In this configuration, solder jumper J8 is set such that both UVcc and 3.3V are connected to Vcc. Vcc is then supplied externally with 3.0V to 3.6V on the Vcc header pin. The internal 3.3V regulator must be disabled in software. Note that the regulator is always enabled after reset or powerup, and is on when the bootloader is running. It is the responsibility of the user application to disable the regulator. The 5V pin still outputs 5V when the USB cable is plugged in. In this configuration, the AVR should be set to run at 8MHz or less. This can be done in software using the prescaler.

USB Shield

Jumper J9 can be soldered to connect the USB shield to ground. The USB specification calls for the USB shield to be connected to ground on the host side only. However, it may be desired to ground this on the device side. An 0603 SMT component may be soldered on the solder jumper pads as well.

Arduino Compatibility

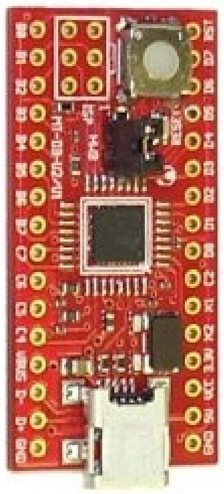
Features

- Arduino core and libraries ported to MattairTech USB boards
- MT-DB-U2: 21 digital, 4 PWM, 8 INT, 13 PCINT, SPI, USART1, 32KB FLASH, 1KB SRAM, 1KB EEPROM
- USB Serial interface replaces USART0
- Hardware maximum speed of 8Mbps (U4/U6) or 2Mbps (U1/U2)
- Can use terminal emulator or serial monitor
- Uses the same methods as the original HardwareSerial.cpp (ie: Serial.println("Hello!"))
- Based on LUFA USB library by Dean Camera (www.fourwalledcubicle.com)
- USART1 also available; can be used at the same time
- Arduino/AVRDUDE compatible CDC bootloader preinstalled on all boards
- Bitlash Arduino command interpreter (bitlash.net) preinstalled on U2, U4, and U6 boards
- All libraries included with Arduino download are now supported
- Bootloader jumps to sketch after upload, reset button or auto-reset returns to bootloader
- HID keyboard and mouse support

Pin Mapping

MattairTech MT-U1/MT-U2 (AT90USB162/ATmega32U2)

Comm	Interrupt	PWM	Digital	AVR Pin	AVR Pin	Digital	Interrupt	PWM	Comm/other
SPI SS	PCINT0		D0	B0	RST				
SPI SCLK	PCINT1		D1	B1	D7	D20	INT7		JUMPER
SPI MOSI	PCINT2		D2	B2	D6	D19	INT6		
SPI MISO	PCINT3		D3	B3	D5	D18	PCINT12		
	PCINT4		D4	B4	D4	D17	INT5		
	PCINT5		D5	B5	D3	D16	INT3		USART1 TX
	PCINT6		D6	B6	D2	D15	INT2		USART1 RX
	PCINT7	TIMER1C	D7	B7	D1	D14	INT1		
	INT4		D8	C7	D0	D13	INT0	TIMER0B	LED
	PCINT8	TIMER1A	D9	C6	C2	D12	PCINT11		
	PCINT9	TIMER1B	D10	C5	X1				
	PCINT10		D11	C4	X2				
				Vbus	3.3V				
				D-	Vcc				
				D+	5V				
				Gnd	Gnd				



Installation

It is recommended to install this separately from existing Arduino 1.x installations.

1. Download and install Arduino version 1.0.5 or higher from http://arduino.cc/en/Main/Software
2. Download the MattairTech_Arduino_1.0.5.zip file from http://www.mattairtech.com/ (see product page). Unzip this file into your arduino user directory (ie: My Documents/Arduino). You may need to create this folder. Do not unzip into the arduino system directory from step 1. If you installed a previous version of the MattairTech Arduino port, move or remove it. It is OK if there are other cores, libraries, or sketches already present.
3. Download and install WinAVR version 20100110 from http://sourceforge.net/projects/winavr/files/WinAVR/20100110/
4. Rename the <arduino system directory>/hardware/tools/avr folder to avr_old. Copy the WinAVR-20100110 folder to <arduino system directory>/hardware/tools. Rename the copied WinAVR-20100110 folder to avr.
5. Create the directory <arduino system directory>/hardware/tools/avr/etc. Then, copy the file <arduino user directory>/hardware/MattairTech/install/avrdude.conf to <arduino system directory>/hardware/tools/avr/etc.
6. Replace the file <arduino system directory>/hardware/tools/avr/bin/avrdude.exe with <arduino system directory>/hardware/tools/avr_old/bin/avrdude.exe
7. Replace the file <arduino system directory>/hardware/tools/avr/avr/include/avr/power.h with <arduino user directory>/hardware/MattairTech/install/power.h
8. Now, plug in the board with the jumper installed so that the bootloader runs. Point the driver installer to the directory <arduino user directory>/hardware/MattairTech/install to install MattairTech_CDC.inf. This same driver is also used for the USB serial interface (if used).

Using Arduino

Because of the similarities with the Arduino Leonardo, please read http://arduino.cc/en/Guide/ArduinoLeonardo first. Within the Arduino IDE, select the appropriate MattairTech board and COM port. There are 2 configurations for each board, 16MHz(5V) and 8MHz(3.3V). You may select 8MHz even if using 5V. When operating at 3.3V, you should select 8MHz. Operating at 16MHz at 3.3V is out of spec, but should work fine at room temperatures. When using the USB serial interface, it is no longer necessary to include the LUFA USB library header file. Then, with the bootloader running, compile and upload your sketch. Note that when using a terminal emulator to communicate with the board, be sure to disconnect before switching to the bootloader. If the jumper is left on, the reset button can be used to switch from the sketch to the bootloader. Pressing reset is not necessary with version 1.0.4 and above. When the sketch has finished uploading, it will run automatically. If you installed the bootloader yourself, be sure that the BOOTRST fuse is set. Note that some example sketches indicate the use of pins using the naming convention

D2, D3, etc. These are Arduino digital pins, not to be confused with port D pins. MattairTech boards are printed with both port pin names as well as sequential numbers indicating Arduino digital/analog pins (0 means D0 or A0, 10 means D10 or A10, etc).

Using Libraries

There are several libraries included with Arduino. Some of these needed simple changes to work with MattairTech boards. If a library was ported, it is included in the MattairTech download and installed in the Arduino user directory with "_MattairTech_Port" appended to the name of the original directory name. This can be seen in the Arduino IDE in File->Sketchbook->libraries and File->Examples. If you see the Files->Examples version of a particular library then you must use it instead of the original library which will still be shown lower on the menu. If there is no Files->Examples version, then you can use the original, which did not require porting. If there is a library you would like to use that is not included with Arduino, email support and I should be able to quickly support it. Often, only pin mappings need to be changed. The I2cMaster library contains a software I2C library that can be used with the MT-DB-U1 and MT-DB-U2, which do not contain I2C hardware.

USB Serial interface

The LUFA directory contains a reorganized subset of the LUFA USB library by Dean Camera (fourwalledcubicle.com). It implements a CDC class device, which appears as a COM port on the host computer. A terminal emulator or the Arduino serial monitor can be used to communicate with the board. Use this interface the same way you would on a standard Arduino (ie: Serial.println()). The interface is nearly the same as the one in HardwareSerial.cpp. For example:

```
void setup() {
  Serial.begin(9600); // The default settings for USB options are used (all enabled)
  pinMode(2, INPUT);
}

void loop() {
  int sensorValue = digitalRead(2);
  Serial.println(sensorValue, DEC);
  //Serial.flush();       // needed if autoflush is not used
  delay(1000);
}
```

Serial.begin() sets up the USB serial interface with a single 32-bit argument. This value is setup by ORing three USB options together along with the optional baud rate. This works because the three options are stored in the upper bits of the 32-bit value. The baud rate is ignored because the fastest speed supported is always used (2Mbps for the AT90USB162 and ATmega32U2, 8Mbps for the ATmega32U4). For example:

```
Serial.begin(9600 | USB_LED_ENABLED | USB_WAITFORCONNECT_DISABLED | USB_AUTOFLUSH_ENABLED);
```

Note that Serial.begin() is no longer needed to support the HID keyboard or mouse. Also note that USB_WAITFORCONNECT_DISABLED is now the default option (it was enabled prior to 1.0.5).

USB_LED_ENABLED, USB_LED_DISABLED

If USB_LED_ENABLED is set, then the LED will display the state of the USB connection (on whenconnected) as well as blink when data is transferred. Otherwise, the LED will be left on and you can manually control it. The default setting is USB_LED_ENABLED.

USB_AUTOFLUSH_ENABLED, USB_AUTOFLUSH_DISABLED

If USB_AUTOFLUSH_ENABLED is set, the upstream buffer (to the PC) will be flushed at periodic intervals. The hardware USB DPRAM is used for the RX and TX buffers. There are actually two buffers per direction in a ping-pong configuration. As one buffer fills up, it is swapped with the other, allowing the USB hardware to read from the filled one, and the user to write to the empty one. Any number of characters can be sent to the upstream buffer without any need to manage it, but it must be flushed at the end of the transmission if USB_AUTOFLUSH_ENABLED is not set. In this case, use Serial.flush(). The default setting is USB_AUTOFLUSH_ENABLED.

USB_WAITFORCONNECT_DISABLED, USB_WAITFORCONNECT_ENABLED

If USB_WAITFORCONNECT_ENABLED is set, Serial.begin() will wait for the host to open a connection before returning. That is, a program like a terminal emulator or serial monitor must connect to the COM port before continuing. This is different than the USB CDC connection. This is useful to prevent the board from sending data before the host is ready, and is required in many cases for microcontrollers with onboard USB (ie: Leonardo). The wait is performed using: while(!Serial); The default setting is USB_WAITFORCONNECT_DISABLED.

USB_AUTORESET_ENABLED, USB_AUTORESET_DISABLED

If USB_AUTORESET_ENABLED is set, the bootloader will be invoked automatically by the Arduino IDE. If USB_AUTORESET_DISABLED is set, a manual reset will be required to enter the bootloader. Note that the HWB jumper must be installed for the bootloader to be invoked, regardless of method. The only exception is when there is no sketch yet installed. With the jumper removed, the sketch (if present) will always run. There is no delay. The default setting is USB_AUTORESET_ENABLED.

Updated Tone.cpp

Tone.cpp now supports multiple simultaneous tone generation (one tone per timer). The MT-DB-U6 currently supports up to 4 simultaneous tones using timers 3, 1, 2, and 0 if not using the RTC, otherwise, timers 3, 1, and 0 are used for 3 tones. The MT-DB-U4 currently supports up to 3 simultaneous tones using timers 3, 1, and 0. A future release may support a fourth tone from timer 4. The MT-DB-U2 and MT-DB-U1 support 2 simultaneous tones using timers 1 and 0. Note that timer 0 has a lower accuracy for tone generation because it is 8-bit (timers 3 and 1 are 16-bit). Note also that use of timer 0 temporarily disables the use of delay(), USB autoflushing, and proper USB LED handling, all of which will return to normal operation once the tone stops playing. Thus, timer 0 is set with the lowest priority. For example, if generating DTMF tones on the MT-DB-U4, timers 3 and 1 will be used. However, the MT-DB-U2 and MT-DB-U1 will both use timer 0 for the second tone.

If timer 0 is used, delay() should not be called while timer 0 is generating a tone. Instead, use _delay_ms(), which is included with avr-libc. If sending data to the USB host (ie: using Serial.print()) before or during timer 0 tone generation, then it must be manually flushed with Serial.flush() prior to calling tone() and after any subsequent printing during tone generation. Otherwise, some data may not be sent until the tone stops and autoflushing returns to normal operation. The USB LED handling (if enabled) will also be disrupted during timer 0 tone generation. During this time, the LED will not be able to change state. If USB traffic occurs, the blink will be delayed until tone generation stops.

The DTMF_Demo sketch demonstrates usage of Tone.cpp for DTMF generation on the MT-DB-U4

CDC Bootloader (Arduino/AVRDUDE)

CDC Serial Driver

The CDC Serial driver allows the board to appear as a COM port. The driver itself is included with Windows, but an .inf file is needed to configure it. Download the .inf file from https://www.mattairtech.com/software/MattairTech_CDC_Driver_Signed.zip. Note that Windows Vista 64-bit, Windows 7 64-bit and Windows 8 require the signed driver. You may need to rename the file so that it has the inf extension. Next, plug in the board with the jumper removed. Windows will then prompt you for the MattairTech CDC Serial driver. Point the installer to the directory where you downloaded the driver and install, ignoring any warnings. Once the driver is loaded, the device will appear as the MattairTech CDC Serial device using a COM port in the device manager.

If you wish, double-click on the CDC Serial device entry in the device manager to configure the driver. Nothing on the port settings tab needs to be changed. We are using a virtual COM port so the settings are ignored. The baud rate will always be as fast as possible. On the advanced tab, you can adjust the FIFO buffer sizes. If you experience any buffering problems (ie: a delayed response to user input), then change both buffer sizes to 1.

CDC Bootloader

The CDC bootloader uses the AVR109 protocol, and can be used withing the Arduino environment, or directly with AVRDUDE. Version 130410 or above is required to support the auto-reset feature (note that several boards that were shipped before 130626 still have the old bootloader). If using a terminal emulator, you must first disconnect before running the bootloader. The bootloader enters programming mode only if the jumper is installed, even when using Arduino auto-reset. The one exception is when the FLASH is empty. Even with the jumper installed, programming mode will NOT be entered if the reset was from the watchdog timer. The one exception to this is when the boot key is enabled and the key matches. The key will match when the Arduino IDE auto-resets the board to enter bootloader programming mode. The key is needed because the Arduino core part of the firmware, which listens for the IDE auto-reset signal, uses a watchdog reset to enter the bootloader. This way, the user application can make use of the watchdog timer. The bootloader will jump to the user application at the end of FLASH programming. Other operations with AVRDUDE, like writing the EEPROM, will not trigger this. Just press reset to get back to the bootloader (as long as the jumper is installed).

The default CDC bootloader has the following compile-time options defined:

```
#define ENABLE_LED_BOOT
#define ENABLE_LED_APPLICATION
#define DISABLE_JTAG_APPLICATION
#define ENABLE_CLKDIV_1_APPLICATION
#define ENABLE_BOOT_KEY
#define ENABLE_RESET_AFTER_PROGRAMMING
#define NO_LOCK_BYTE_WRITE_SUPPORT
```

An alternate version with the above options undefined is available on the website named Bootloader_no_options.hex. Use it if the default options interfere with your application. For example, you may disconnect the LED and use the pin as an analog input.

When using the auto-reset feature of Arduino, the boards.txt file must currently list the bootloader directory as caterina (the bootloader used on the Leonardo). The actual bootloader is a modified version of the LUFA CDC bootloader by Dean Camera (lufa-lib.org). It resides in the mtdbxx folder (where xx corresponds to the board you have). So, if you wish to use the Arduino IDE to burn the bootloader, you must temporarily change the appropriate entry in the boards.txt file to point toward the actual bootloader directory. Change it back to caterina when finished to re-enable auto-reset.

Example for Windows:

```
avrdude -p m32u4 -c avr109 -P COM5 -U flash:w:"bitlashdemo_MT-DB-U4.hex"
```

Example for Linux:

```
avrdude -p m32u4 -c avr109 -P /dev/ttyACM0 -U flash:w:"bitlashdemo_MT-DB-U4.hex"
```

Arduino environment:

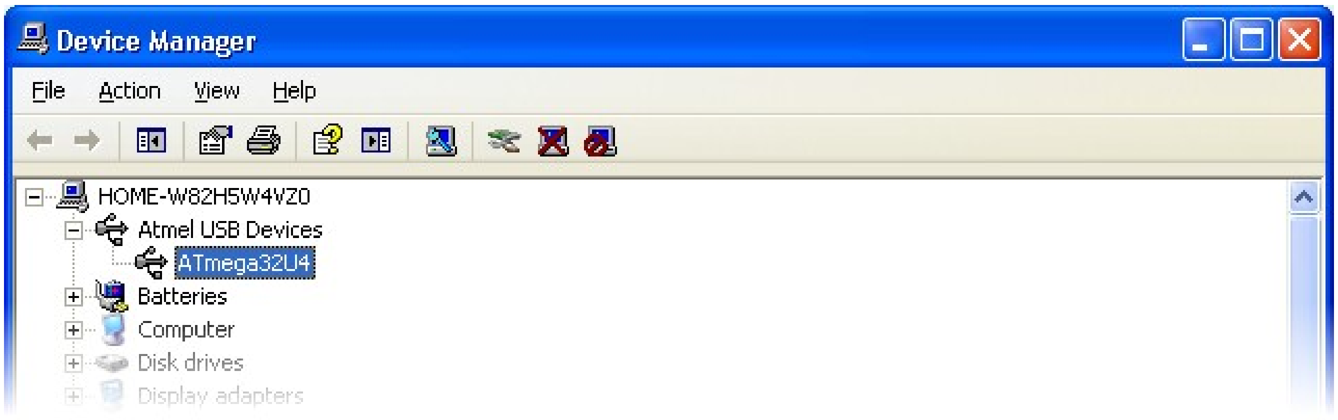
Be sure to select the COM port. Then upload your sketch with the Upload button.

DFU Bootloader (FLIP/dfu-programmer)

Installation

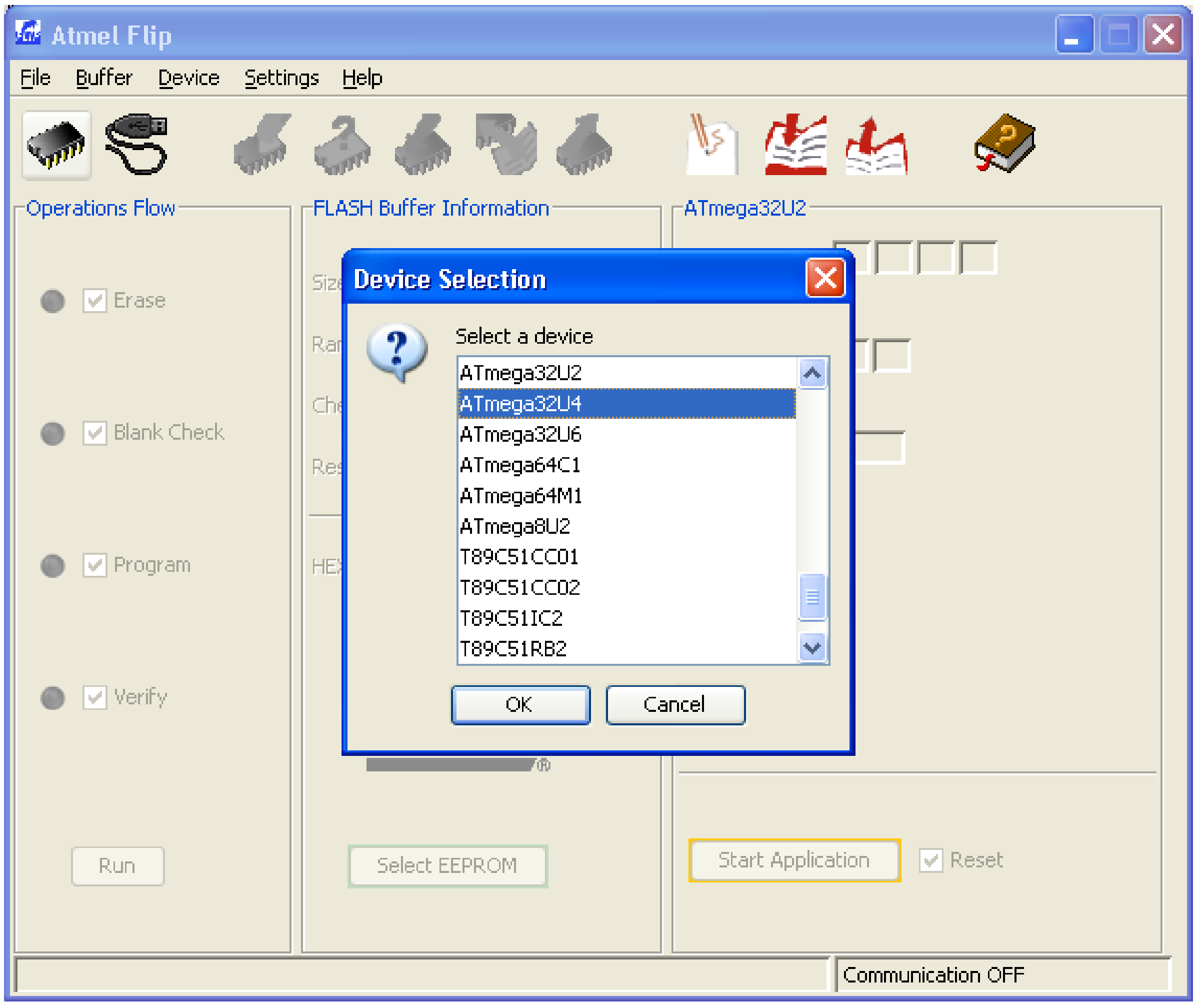
FLIP is a graphical utility used to load firmware into the ATmega32U2. FLIP includes the DFU bootloader driver. It supports Windows XP through Windows 7 (32 or 64 bit). Download FLIP 3.4.2 or higher from http://www.atmel.com/dyn/products/tools_card.asp?tool_id=3886 and install.

Once FLIP is installed, the DFU bootloader drivers can be loaded. Install the HWB jumper and power-up the board (or press reset). This will enter the DFU bootloader. The LED should be pulsing. Windows will then prompt you for the ATmega32U2 driver. By default, this is located in the Program Files/Atmel/Flip 3.4.2/usb directory. Point the installer to that directory and install. Once the driver is loaded, the device will appear as the ATmega32U2 device under Atmel USB Devices in the device manager.



FLIP

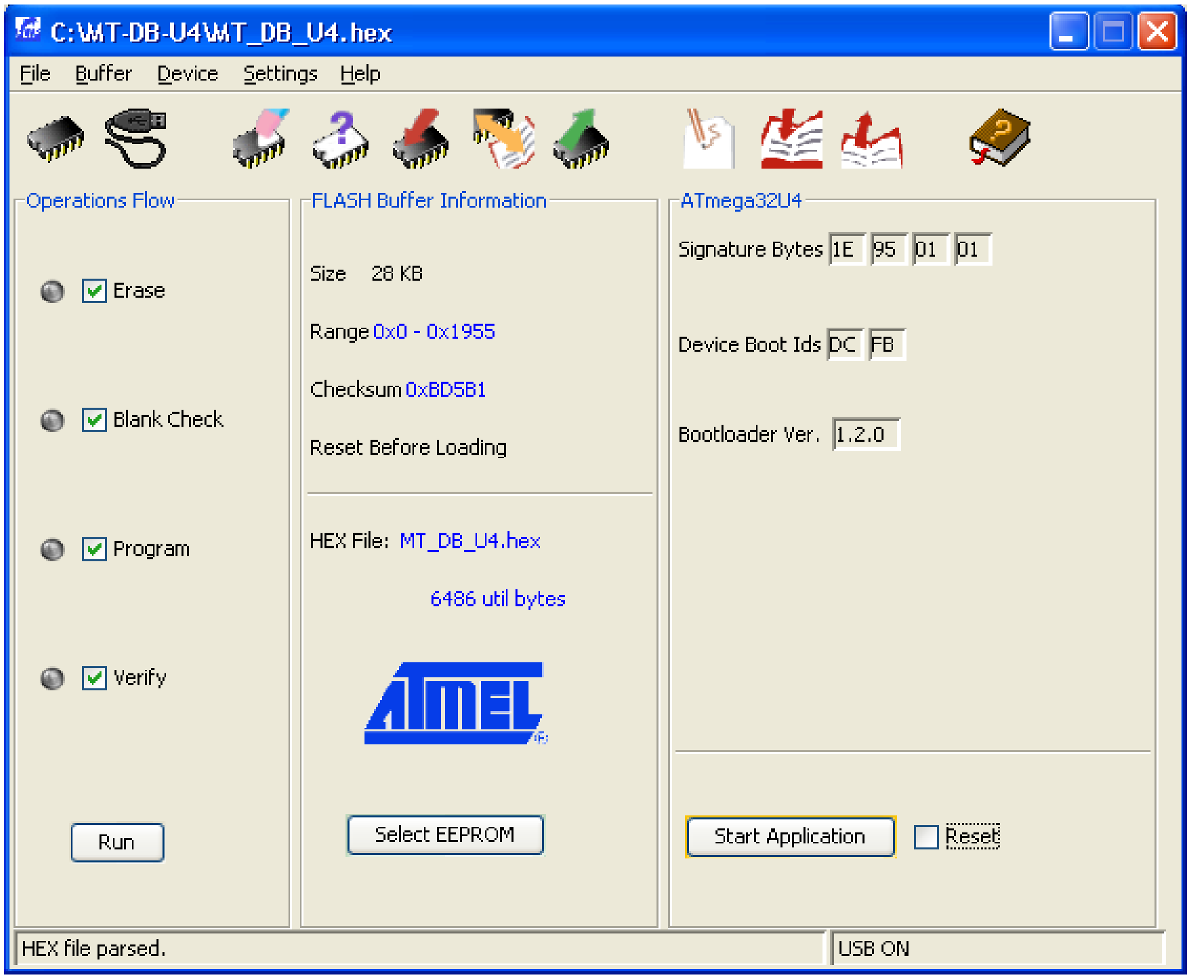
Install the HWB jumper and power-up the board (or press reset). This will enter the DFU bootloader. The LED should be pulsing. Now launch the FLIP utility. When it has loaded, click on the chip icon and select the Atmega32U2.



Select a device

ATmega32U2
ATmega32U4
ATmega32U6
ATmega64C1
ATmega64M1
ATmega8U2
T89C51CC01
T89C51CC02
T89C51IC2
T89C51RB2

Next, click on the USB icon, select USB, then connect. The screen should now show information about the ATmega32U2. Click on the File menu, and open the appropriate hex file. More information will appear about the program. Be sure that erase is checked. The firmware cannot be loaded unless the flash is erased first. Program must be checked. Verify should also be checked. Now click on the Run button in the lower-left of the screen, and the firmware will be quickly loaded onto the ATmega32U2.


C:\MT-DB-U4\MT_DB_U4.hex

☑ Erase

☑ Blank Check

☑ Program

☑ Verify

Size 28 KB

Range 0x0 - 0x1955

Checksum 0xBD5B1

Reset Before Loading

HEX File: MT_DB_U4.hex

6486 util bytes

Signature Bytes 1E 95 01 01

Device Boot Ids DC FB

Bootloader Ver. 1.2.0

☐ Reset

HEX file parsed.

USB ON

You may also program the EEPROM. If so, click on Select EEPROM at the bottom. Then, click on the File menu and open the appropriate eep file. You will have to change the file filter to allow you to see the eep file. Note that eep files are just hex files but with the eep extension instead of hex. More information will appear about the file when selected. Both Program and Verify should be checked. Click run to program the EEPROM.

You can run your application without removing the jumper or pressing reset by unchecking the reset box and pressing the “Start Application” button (lower right).

dfu-programmer

dfu-programmer is a command line utility used to program the ATmega32U2 that runs under Linux. A DFU driver installation is not required. Download version 0.5.4 or higher from http://dfu-programmer.sourceforge.net/ . The following commands can be used:

```
dfu-programmer atmega32u2 erase
dfu-programmer atmega32u2 flash-eeprom YourHex.eep (if applicable)
dfu-programmer atmega32u2 flash YourHex.hex
dfu-programmer atmega32u2 start (to jump to application section without reset)
```

Running Bitlash Demo

Bitlash

Bitlash is an open source interpreted language shell and embedded programming environment. The preinstalled Bitlash demo was compiled in the Arduino environment and supports Arduino functions (ie: dw() for digitalWrite()). A terminal emulator (recommended) or the Arduino serial monitor may be used. See the CDC Bootloader section for details on installing the CDC Serial driver. The following example saves three functions to EEPROM. It is then run in the background, pulsing the LED using analog write (PWM):

```
bitlash here! v2.0RC4 (c)2011 Bill Roy, bitlash.net -type HELP- 1706 bytes free
> print free, " bytes free"
1702  bytes free
> pinMode(13,1)
> d13=1
> x=255;d=0;
> function brighter {if (x==255) {d=0;} else { a13=++x; snooze(2);}}
saved
> function dimmer {if (x==0) {d=1;} else {a13=--x; snooze(2);}}
saved
> function pulseLED {if (d==0) {dimmer();} else {brighter();}
saved
> ls
function brighter {if (x==255) {d=0;} else { a13=++x; snooze(2);}};
function dimmer {if (x==0) {d=1;} else {a13=--x; snooze(2);}};
function pulseled {if (d==0) {dimmer();} else {brighter();};
> run pulseled
> ps
0: pulseled
> stop 0
>
```

Documentation for Bitlash is available at http://bitlash.net/wiki/docindex

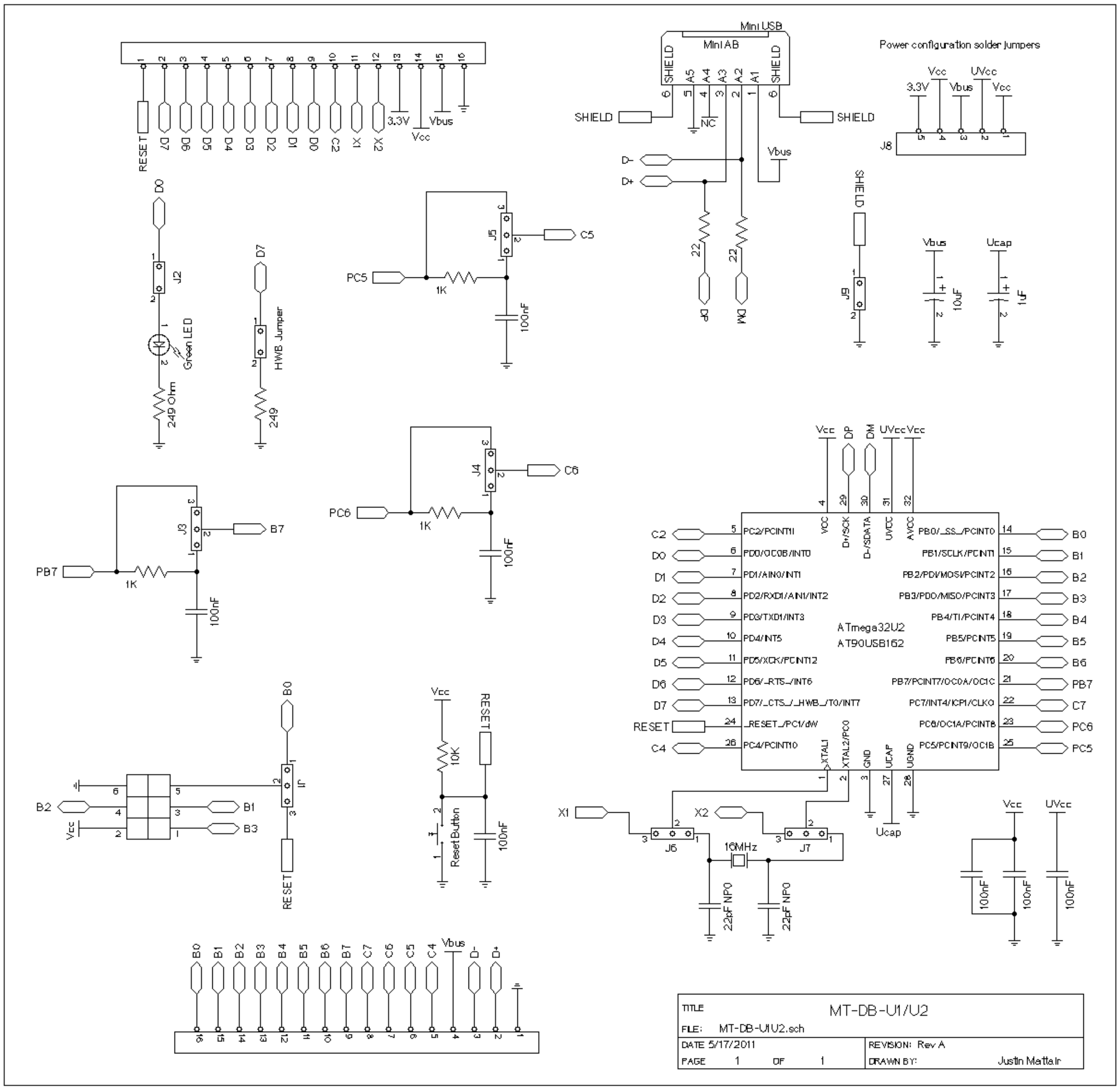
Commands	arg else function help if ls peep print ps return rm run stop switch while
Functions	abs ar aw bc beep br bs bw constrain delay dr dw er ew free inb max millis min outb pinmode printf pulsein random shiftout sign snooze

Old Demo Program

The old demo program makes use the use of the MT-DB-U2 as a CDC device (virtual COM port). This is one of the most common ways to connect to a PC over USB. It uses Dean Camera's open-source LUFA USB library available at http://www.fourwalledcubicle.com/. The LUFA download includes many examples that can be easily compiled for the ATmega32U2.

See the CDC Bootloader section for details on installing the CDC Serial driver. The old demo requires an ANSI terminal to allow drawing of the menu system. If you see garbage on the terminal screen, click on the configuration icon and change the emulation to ANSI (or ANSIW). After connecting, a message that reads “Press any Key” is printed periodically. If you do not see this message, just press any key to continue.

Schematic



Mini USB
Mini AB
SHIELD
D-
D+
Vbus
Power configuration solder jumpers
3.3V
Vcc
Vbus
UVcc
J8
RESET
D7
D6
D5
D4
D3
D2
D1
D0
C2
X1
X2
J2
Green LED
249 Ohm
HWB Jumper
249
J5
C5
PC5
1K
100nF
J4
C6
PC6
J3
B7
PB7
J9
10uF
1uF
Ucap
22
DP
DM
ATmega32U2
AT90USB162
J1
B0
B1
B2
B3
10K
Reset Button
X1
X2
J6
J7
16MHz
22pF NP0
TITLE MT-DB-U1/U2
FILE: MT-DB-U1U2.sch
DATE 5/17/2011
REVISION: Rev A
PAGE 1 OF 1
DRAWN BY: Justin Mattair

Troubleshooting / FAQ

Nothing yet

Support Information

Please check the MattairTech website (http://www.MattairTech.com/) for firmware and software updates. Email me if you have any feature requests, suggestions, or if you have found a bug. If you need support, please contact me (email is best). You can also find support information at the MattairTech website. A support forum is planned. Support for AVRs in general can be found at AVRfreaks (http://www.avrfreaks.net/). There, I monitor the forums section as the user physicist.

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Acknowledgments

Thanks to Dean Camera (http://www.fourwalledcubicle.com/) for his excellent LUFA library and bootloaders. Thanks to the members of AVRfreaks (http://www.avrfreaks.net/) for their support. Finally, thanks to Atmel for creating a great product, the AVR microcontroller.

Legal

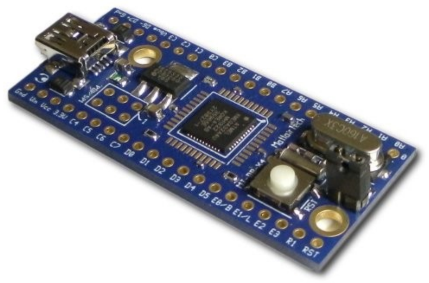
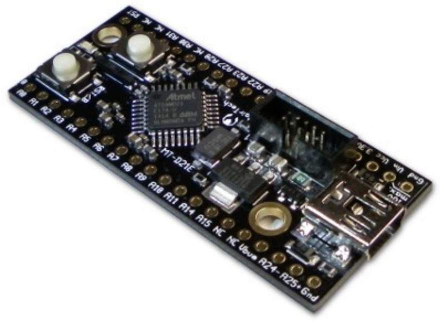
Appendix A: Precautions

WARNING
Care must be taken when configuring the solder jumpers. It is possible to cause permanent damage to the device or the power supply by improperly setting the jumpers. Do not change any jumpers while the unit is powered. When using the microcontrollers internal regulator to power itself, be sure not to exceed the regulator maximum current output.

CAUTION
The MT-DB-U2 contains static sensitive components. Use the usual ESD procedures when handling.

CAUTION
Improper fuse settings may result in an unusable AVR. Be certain that you know the effects of changing the fuses, that you understand the convention used for describing the state of the fuses (programmed = 0), and that you are using an appropriate programming speed before attempting to change fuse settings.

Appendix B: Other MattairTech Products

●	**ZeptoProg II AVRISP mkII Programmer** ● AVRISPmkII compatible AVR Programmer ● Supports all AVRs with ISP, PDI, or TPI ● Optional 5V output via headers to target board, with standard jumper and PTC fuse ● 4-channel Logic Analyzer ● Serial bridge / pattern generator / SPI interface ● GPIO / PWM / frequency input & output ● Atmel Studio / AVRDUDE support ● Target board voltage of 2V to 5.5V via level-shifted pins on two main headers
●	**MT-DB-U6 USB AVR development board** ● AT90USB646 / AT90USB1286 USB AVR ● 64KB/128KB FLASH, 4KB/8KB SRAM ● 5V, 500mA LDO regulator (3V-30V input) ● Auto power source selection IC (USB/External) ● 16MHz and 32.768KHz crystals ● Arduino compatible ● CDC or DFU bootloader
 ●	**MT-DB-X4 USB AVR XMEGA board** ● ATxmega128A4U USB XMEGA AVR ● 128KB FLASH, 8KB SRAM, 2KB EEPROM ● 3.3V LDO regulator (low quiescent current) ● 16MHz and 32.768KHz crystals ● LED, boot jumper, PDI header ● Reset button, mounting holes ● USB DFU bootloader preinstalled
 ●	**MT-D21E USB ARM Cortex M0+ board** ● ATSAMD21E17A or ATSAMD21E18A (32-pin) ● 128KB/256KB FLASH, 16KB/32KB SRAM ● Onboard 3.3V, 250mA LDO regulator (2uA quiescent) ● 16MHz and 32.768KHz crystals ● USB connector (power by USB or external up to 15V) ● Blue LED, 10-pin Cortex header, 2 buttons, I2C pullups ● USB Mass Storage Bootloader (no programmer required)